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Fig. 1.—Glaciated Surface, Turnavik Island, Labrador.

Fig. 2.—A Dike Chasm showing preglacial decay. Turnavik Island, Labrador.

EVIDENCE OF GLACIATION IN LABRADOR AND BAFFIN LAND.

By Ralph S. Tarr, Ithaca, N. Y.

(Plate X.)

Route. The observations recorded in this paper were made by the writer during the summer of 1896, while a member of the Peary expedition to Greenland.* The steamer Hope, which carried the party, passed near the land along the entire eastern coast of Labrador, and an almost continuous view of this coast was obtained. Only one stop was made, at the island of Turnavik, in lat. 55° 15′. A landing was also made at Big island, in Hudson's strait, in lat. 63° and long. 71°, and several stops on the main Baffin Land coast, just north and northeast of Big island. On the return from Greenland, a stop was made at Niantilik harbor, on Black Lead island, in lat. 65°, long. 67°, on the south shore of Cumberland sound.

Turnavik Island, Labrador. As seen from the steamer, nearly the entire eastern margin of the Labrador peninsula has the rounded contour which is so characteristic of glaciated lands. This is particularly well shown on the hills near Turnavik, which is an island off the Labrador coast. The elevation of Turnavik is only two or three hundred feet in its highest point, and like most of these northern lands, the surface is for the most part bare rock, with very little covering excepting in the protected valleys, where, in some places, there is a deposit of till, and frequently a covering of peat. The rock is a porphyritic gneiss crossed by igneous rocks, and especially by diabase dikes.

Upon Turnavik island signs of glaciation are everywhere present; the rock surfaces are roches moutonnées forms, with very perfect outline, and upon these, glacial grooves and striæ abound. The perfection with which these delicate scratches are preserved in exposed places tells of the recency of the ice withdrawal; but perhaps not so much as would at first appear. Since the ice left this region, the lower portions of the coast have been submerged beneath the sea, and hence for

*Besides myself, the members of the Cornell party were Prof. A. C. Gill, E. M. Kindle, J. O. Martin, T. L. Watson, and J. A. Bonstell. Prof. G. H. Barton was with us much of the time in this part of the expedition. (See Am. Geol., xviii, 1896, 379.)

some time protected from the action of the weather. On Baffin land, where the question of post-glacial elevation was studied,* it was found that there was a marked difference in the amount of weathering above and below the zone of former water covering. It is, therefore, probable that the freshness of the striæ near the sea level at Turnavik is only partly due to the recency of the ice retreat.

Although the hills of Turnavik are well rounded, and show signs of decided ice scouring (Fig. 2, Pl. X), it is evident that the glaciation did not succeed in destroying even the details of the pre-glacial topography. Evidence of this is particularly strong in the dike valleys. These, even though extending at an angle to the direction of ice motion, are pronounced features of the present topography (Fig. 2, Pl. X). The pre-glacial decay along the line of these dikes was deeper than that on the enclosing gneisses, and the action of the ice scouring has not been sufficient to lower the gneisses to the level of this decay. Hence in various directions the island is crossed by dike chasms, which are deep and narrow, as well as remarkably continuous. In some cases at least the disintegrated material has all been removed, and the fresh diabase rock exposed in the bottom of the chasm. In other cases there is a layer of till, peat, or foreign rock in the bottom of the chasm; and hence in these places it is impossible to determine by surface indications whether all the decayed diabase has been carried away. This evidence of slight scouring is in harmony with that found in Baffin land and Greenland, and also in parts of New England.† It shows that pre-glacial decay was deep, and that the general ice scouring did not lower the surface far below the zone of decay in the weaker members of the rock series.

Northern Labrador. Near the northern end of Labrador the first doubt concerning the presence of ice action arises when the Kig-La-Pait mountain comes in view; and northward to Ogua-Lik and cape Mugford, and even as far north as the Four Bears (from Lat. 57° to 60°) the same doubt arises

*See Watson, Journ. Geol., v, 1897, 17.

†See Shaler on the Geology of Cape Ann, Ninth Annual Report U. S. Geol. Survey. Pl. LXII. Prof. Shaler interprets this as the result of sea action, but my studies lead me to the conclusion that the dike valleys are preglacial.

because of the angularity of the topography. From the evidence of the topography I thought that these high mountains, which rise from near the sea to elevations of from two to five or six thousand feet, had escaped ice scouring, though the rounded contours of the valleys indicated the presence of ice action in them. My first thought was that, though the ice had spread through the valleys, the elevated peaks had risen above the surface as peninsulas and nunataks, like those of the present Greenland coast. Later study in Greenland proved the danger of drawing inferences concerning the absence of glaciation upon the basis of topographic form as seen from a steamer several miles from the coast.* The rounded outline so characteristic of an ice-scoured country is good positive evidence of ice action, but the *absence* of such action is not of equal value in proof of the opposite. When the pre-glacial surface was high and rugged, the same amount of scouring that rounded the lower hills may have failed to produce rounded contours on the higher lands. Moreover a peak projecting into the ice is less eroded than the valleys whose surface is covered by the ice currents of greatest activity. In addition to this, the lower lands are longest covered, being the first reached and the last abandoned by a general ice sheet.

Therefore, although there is a striking difference in topography between the hills near Turnavik and the mountains around cape Mugford, I shall be very much surprised if future study proves that the higher hills were not covered and perceptibly modified by ice action. During the *last* stages of ice action these mountains no doubt rose above the ice as land. It was a source of disappointment that other plans prevented our landing and studying this highland portion of the Labrador coast. This region offers a splendid opportunity for determing the thickness of the northern portion of the continental glacier which spread out from the Labrador center; and in some one of the northern expeditions it should be made a stopping place for this purpose. The rounded topography of glacial regions reappears on the peninsula which forms the northeastern portion of Labrador.

*This point is discussed in a paper to be published soon in vol. VIII, Bull. Geol. Soc. Am.

Southern Baffin Land, on Hudson's Strait. On Big island, and on the main Baffin land to the north of it, evidence of glacial action was found on all the hills that were visited. The rocks of this region are gneisses, and on the mainland these are very garnetiferous. Post-glacial disintegration has weathered these rocks very decidedly. The pre-glacial topography, which still forms the most striking features of the present land form, consists of valleys and hills which are mainly parallel to the strike of the rocks (about N 10°-30° E, magnetic). So numerous are these valleys that the surface outline is exceedingly irregular. Into some of the strike valleys the sea at present enters, and near the shore, drowned alleys and hills, completely submerged beneath the sea, form alternate channels and reefs, so that navigation near the shore is very dangerous. Several times the ship passed near some of these submerged hill tops, and once ran upon one, staying there until the tide went out and rose again to float her off.

Not merely are there these large pre-glacial valleys, but innumerable smaller ones, also parallel to the strike. So numerous are these that the surface of the hills is corrugated by ridges and minute valleys, where the hard and soft layers alternate. It is evident that these irregularities of minor degree are not of post-glacial origin, for the valleys are occupied mainly by ice-derived blocks of rock and by till (below the zone of former sea level, by sea-made deposits). The valleys extend diagonally to the direction of ice motion, and hence were not ground out by ice erosion. They certainly represent irregularities of pre-glacial origin, which the ice erosion has not been able to wear away; and, comparing the evidence from this with that found at Turnavik, it seems evident that less down-cutting was accomplished by the Baffin Land ice cap than by the Labrador sheet which overspread Turnavik.

The land in the southern portion of Baffin land rises to an elevation of over 700 feet within a few miles of the shore, and the ice has covered all of the hills. It is perfectly evident at a glance, and can be proved without even visiting the shore, that notwithstanding the many irregularities in detail of surface outline, the general topography is that of smooth and somewhat rounded contours. The action of the ice upon the higher hills is also shown by the roches moutonnées which

abound; and the condition of the rock is likewise proof of ice action: for, although much post-glacial weathering has occurred, there is an absence of the quantities of decayed rock and talus that would be present in a region which had long been exposed to the weather. Glacial striæ of distinct kind were not seen; the weathering of the exposed rocks having been too great for them to remain. Some broad and rather deep grooves, apparently of this origin, extended N. 50°–60° E. (magnetic), and this coincides with the direction of the ice movement as determined by the form of the moutonnées hills. In the valleys there are deposits of glacial material, but till is so scarce that the surface is almost entirely either bare rock, or else blocks of gneiss derived by post-glacial frost action.* Transported pebbles of quartzite, slate, and fossiliferous limestone were frequently found on the hills and in the valleys, but the time at our disposal would not permit us to trace these to their source.

Cumberland sound, Baffin Land. Very nearly the same conditions were present in Cumberland sound, though the details of the pre-glacial topography are perhaps even more perfectly preserved. The surface of the hills is extremely irregular, and valleys and ridges of minute size, distinctly of pre-glacial origin, abound. On this part of Baffin land also, the glacier extended at least as high as 700 feet, and nothing in the topography indicated that the ice did not cover even the highest hills that could be seen. It was astonishing to find how little effect in smoothing the surface was accomplished by the ice invasion of this land; but very nearly the same condition exists on those parts of the Greenland coast, which were studied in detail. It is noticeable near Cumberland sound, as well as in Turnavik, and in Hudson's strait, and indeed in Greenland, that there are many basins of small size, surrounded entirely by rock. While some of these have no doubt been scoured out by differential ice erosion, the position of many of them along the line of weaker rocks, indicates that they represent differential pre-glacial weathering. The advance of the ice in these cases has served to remove the decayed rock, and perhaps

*This notable absence of drift deposits is found throughout the northern regions so far visited. For some reason the ice that passed over these did not have much drift, just as now, the Greenland glaciers are not heavily laden.

to deepen the depressions formed by this action, though ice erosion would not in this case be the prime cause for the basin.

Recency of ice withdrawal. Notwithstanding the absence of distinct rock striæ, it is evident, for several reasons, that the ice has not long been away from Baffin land. The marked weathering of the surface rock suggests considerable length of time; but in using this as a basis for an estimate, it must be remembered that the severe weather changes of the Arctic, evidently produce marked results in weathering in a very short time.* In the till beds, which were found in greater thickness and abundance in Cumberland sound than in the other places that have been described, there is much less evidence of modification. The striæ on the pebbles are still distinct, and the till not markedly decayed, nor even the weaker pebbles disintegrated. Weathering on the exposed and friable gneissic bed rock has been far more rapid than in the unconsolidated deposits in which frost action is able to produce less effect.

Evidence of recency of the ice withdrawal is also furnished by the lakes of Baffin land. Some of them have two outlets and others have more. This certainly could not have been possible had the water been overflowing the rims of the basin for any considerable length of time. It would not be long before one of the outlets, in its action of down-cutting, would so exceed the rate of work of the others that all but one would be abandoned. Pointing toward the same conclusion of recency is the fact that even where torrents enter shallow lakes from the higher hills, the materials that have been brought by the streams have not yet been able to build perceptible deltas in most of the lakes.

Conclusions. The conclusions to be reached from this very brief reconnaissance study of parts of Labrador and Baffin land are, in the first place, that all of the land, excepting possibly the highest parts of Baffin land and Labrador, has been buried beneath an ice sheet. The possible exceptions, in all probability, are not real cases of unglaciated land, but rather high land that rose *into* the ice, and in the early and later stages of glaciation extended *above* it, as is the case in Green-

*See Tarr, Am. Geol., xix, 1897, 131.

land itself at present. The direction of ice movement in Labrador was not determined excepting at Turnavik, where it was off shore. In Baffin land it was difficult to tell how the ice moved, because the striæ were destroyed by post-glacial weathering; but on the southern side the ice movement was apparently southeastward, as if Baffin land had been a separate center of ice dispersion.

The glacial action produced more effect in the down-cutting of the surface in Labrador than in Baffin land, for the surface features of the former are very much more rounded than those of the latter. Even near Turnavik, the ice cutting did not succeed in lowering the surface down to the level of the zone of weathering in the weaker rocks. In Baffin land the down cutting of the surface was even less pronounced. Both in Labrador and Baffin land there is evidence that the ice has withdrawn from these regions in very recent times. By comparison with studies that have been made in parts of New England it seems that the period since the ice left is much shorter in the northern lands. Comparing these northern regions with New England it seems certain also that the action of ice erosion has produced less effect upon the topography of the northern than the southern regions. On the other hand, as we proceed northward the effects of post-glacial weathering become more and more pronounced, so that the recency of the ice uncovering is more and more masked.

ESKERS INDICATING STAGES OF GLACIAL RECESSION IN THE KANSAN EPOCH IN NORTHERN ILLINOIS.

By Oscar H. Hershey, Freeport, Ill.

(Plate XI.)

Introduction.

The following pages present the result of an investigation into the character and origin of a remarkable series of ridges and knolls of stratified gravel and sand, situated mainly in the Pecatonica basin in northwestern Illinois and the adjacent portion of Wisconsin. They constitute a very important part of a drift sheet which, although unevenly distributed, is very thin and presents no true moraines. It has now become well known as the Kansan drift sheet, and it is exposed in a